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Stable Isotope Studies on Granulites from the high grade terrain of Southern India

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Carbon dioxide-rich fluid inclusions from the high grade terrane of South India have been cited as evidence for granulite metamorphism resulting from pervasive carbon dioxide flushing, possibly from a deep seated source. This study tests the model of external CO_2-buffering and investigates the source of the carbon dioxide.

The terrain is thought to be of Archean age, and is segmented by Proterozoic shear zones. Samples of massive charnockites, precursor amphibolite gneisses and gneiss-incipient charnockite pairs from eight quarries throughout the high grade region have been analysed and representative results are shown in Table 1. Gas was extracted from fluid inclusions within quartz grains by a stepped heating technique[1].

All samples measured show similar and simple release patterns. A maximum carbon dioxide release is found between 600°C and 800°C, which is characterised by the isotopically heaviest carbon, ranging between -12‰ and -7‰. Optical fluid inclusion studies (M. Santosh) show that the majority of fluid inclusions in these samples rupture between 500°C and 800°C confirming them as the source for the analysed carbon dioxide.

The data when plotted on figure 1 illustrate that no systematic isotopic variation can be seen between gneiss and incipient charnockite as found in Kabbaldurga and Ponmudi. Furthermore massive charnockite which is exposed on a regional scale as in Madras or the Nilgiris has similar isotopic characteristics to incipient charnockite.

However the data clearly show that in all gneiss-incipient charnockite pairs quartz from the charnockite contains about three times more carbon dioxide than quartz from the gneiss. In the case of charnockites from South Kerala it is possible that some CO_2 results from oxidation of the graphite, which is present in significant amounts. However in Kabbaldurga and Koddakad where no graphite or other source of carbon is present fluid influx from an external source is the probable mechanism.

The uniformity of the $\delta^{13}C$ values of both gneisses and charnockites (averaging -10 ± 2‰) from a wide area of South India indicates either that externally buffered CO_2 equilibrated with the gneiss or that the CO_2 now in the incipient charnockites represents a redistribution of the CO_2 in the precursor gneiss during charnockite formation. However we suggest that the greater abundance of CO_2 in incipient charnockites is compliant with an externally buffered CO_2 source rather than a closed system process. It seems unlikely that the source of the CO_2 can be wholly derived from crustal carbon (i.e. carbonates 0‰ and organic derived carbon -20 to -30‰) because of the apparent isotopic uniformity of the fluid. The range of $\delta^{13}C$ values for South Indian gneisses and charnockites are comparable to the composition of similar high pressure fluid inclusions preserved in upper mantle xenoliths (-8 to -14‰)[2] suggesting that such fluids may contain a significant mantle component. Many of the problems identified by this study may be resolved by ongoing analyses which will determine the carbon isotope characteristics of gneisses not associated with charnockites, and also the carbon isotope characteristics from fluid inclusions within charnockite phases critical to granulite formation such as biotiite and pyroxene.

References cited:

1 Santosh M. et al. (1987) J. Geol. Soc. India In press.
2 Mattey D.P. et al. (1987) TERRA cognita Vol 7, p 31-37.

AREA	LOCALITY	ROCK TYPE	PEAK YIELD (ppm)	d13C
NILGIRIS	WELLINGTON (OOTY)	MASSIVE CHARNOCKITE	61	-8.9
MADRAS	PALLAVARUM	MASSIVE CHARNOCKITE	54	-9.6
BANGALORE	KABBALDURGA	GNEISS	10	-8.7
		INCIPIENT CHARNOCKITE	22	-9.5
PALGHAT GAP	KODDAKAD	GNEISS	17	-8.1
		INCIPIENT CHARNOCKITE	48	-7.9
SOUTH KERELA	PONMUDI	GNEISS	22	-10.1
		INCIPIENT CHARNOCKITE	76	-10.4
	KOTTAVATUM	GNEISS	11	-8.9
		INCIPIENT CHARNOCKITE	34	-9.2
	MANALI	GNEISS	42	-11.7
		INCIPIENT CHARNOCKITE	150	-7.6
		BASIC GRANULITE	48	-12.4

TABLE 1

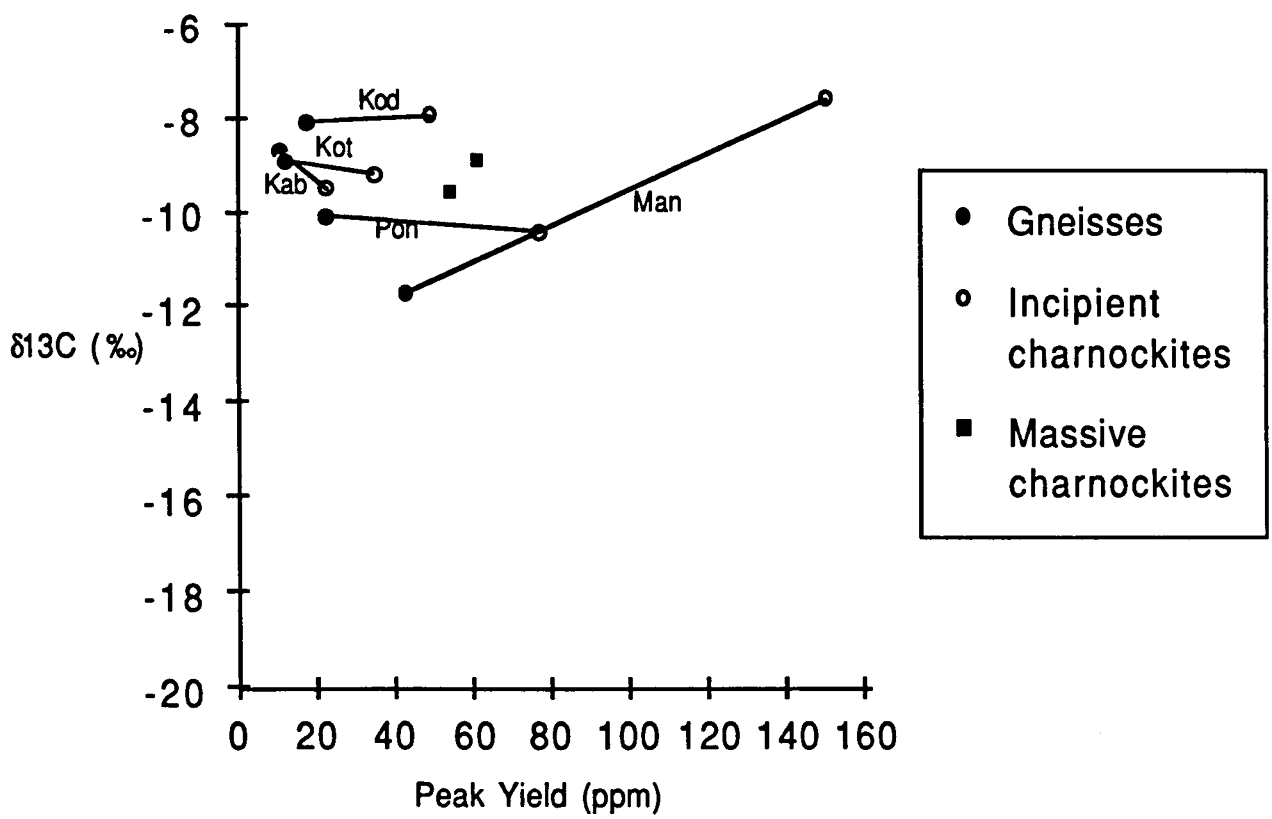

Figure 1